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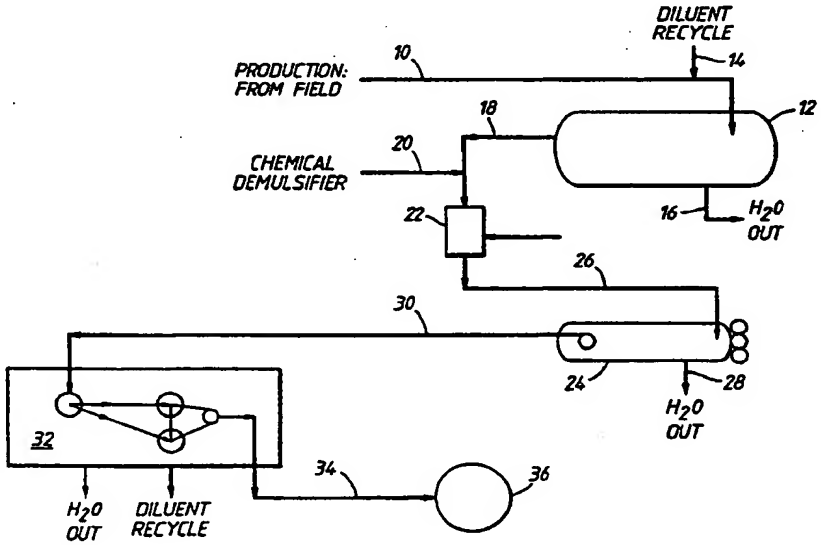

(57) Abstract

A method for breaking an emulsion comprising oil and water into oil and water phases comprising treating the emulsion with a chemical demulsifier and passing the mixture through a hollow chamber (22) having a uniform cross section and subjecting the mixture to acoustic energy in the frequency range of about 1.0 to 10.0 kHz, preferably 1.25 kHz, to enhance breaking the emulsion into a water phase and oil phase. The oil phase is then separated from the water phase by gravity separation and recovered. The sonic energy is generated by a transducer (64) attached to the mid-section of the upper or lower outer surface of the hollow chamber (22). For emulsions containing light oils having an ALI gravity greater than 20 and water, the emulsion can be broken by the use for acoustic energy in the frequency range of about 1.0 to 10.0 kHz without the addition of chemical demulsifiers.

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METHOD AND APPARATUS FOR BREAKING HYDROCARBON EMULSIONS

This invention relates to a method and apparatus for breaking hydrocarbon emulsions, particularly hydrocarbon emulsions containing oil and water into separate phases. More particularly, the present invention relates to a method and apparatus for enhancing the separation of water-in-oil emulsions containing petroleum recovered from underground reservoirs into water and crude oil phases by employing sonic acoustic energy in the frequency range of about 1.0 to 10.0 kHz whether alone or in conjunction with chemical demulsifiers.

In oil fields, water usually is co-produced with crude oil and becomes entrained with the oil to become an emulsion. The crude oil must generally be free of water (0.5% or less) before it can be sold and transported in pipelines. The complexity of separating mixtures of water and oil depends upon the physical form of the water. Where the mixture has only "free" water, the water will separate readily from the oil because of the differences in gravities of the water and oil. This type of separation presents no problem other than providing a vessel in which water-oil phase separation can occur. However, the water can be dispersed throughout the oil in very minute particles, usually with diameters less than 25 microns. This mixture may be termed an emulsion and is very difficult to separate into water and oil phases.

In these emulsions, the small particles of water are dispersed in the oil in a stable condition for several reasons. First, the area of the interface between oil and water in a stable emulsion is very substantial. For example, the interfacial area of one gallon (0.005 m^3) of water dispersed within oil would range from about 1,000 to 300,000 square feet (93 to 28000 m^2). The interfacial area of the water in the oil is stabilized against coalescence by two factors in a stable emulsion. The minute size of the dispersed water is one factor to provide an atmosphere necessary for emulsion stability. The second factor is the presence of emulsifying agents or surfactants which completely coat the interfacial area to form a protective high-viscosity film that surrounds and stabilizes

the dispersed water within the continuous oil phase. This film prevents the coalescence of the dispersed water in the emulsion into separate water and oil phases.

The breaking of emulsions in which water is dispersed in the continuous crude oil phase requires performing certain functions. Initially, the interfacial protective film surrounding the dispersed water within the emulsion must be weakened or destroyed. Then, the particles of water must coalesce into droplets of water which can undergo settling through the effects of gravity. Thereafter, the coalesced droplets of water are separated as a water phase from the oil phase.

Breaking of emulsions may be achieved by physical and chemical treatments, application of heat, and electrical methods. Generally, the methods for breaking a water-in-oil emulsions usually employ a combination of these treatments. In many instances, chemical demulsifiers may be employed for assisting in the breaking of the protective film which surrounds the dispersed water. The demulsifiers are added to the emulsion to counter-act the effects of the emulsifiers which provide the stability of the dispersed water particles in the continuous oil phase. The demulsifier is uniformly distributed throughout the emulsion so as to be present at all interfaces between the water and oil before the emulsion is processed in a treating facility.

There are a multitude of complex chemical compositions which serve as demulsifiers for breaking water-in-oil emulsions. Surface-active materials have been used successfully as demulsifiers. The demulsifiers usually have a variety of polar components with a preferred solubility ranging from predominantly oil-soluble to predominantly water-soluble. An emulsifying agent stabilizes an emulsion which effect can be counteracted by a demulsifier.

The selection of a demulsifier for breaking a particular emulsion may be based upon actual tests and trials performed in the emulsion. Several methods are available to screen the demulsifiers. Usually the type of the demulsifier, and its amount in use, are best established by experimentation directly

at the facility used to separate the emulsion into water and oil phases.

Many types of organic and inorganic materials help stabilize emulsions. Inorganic solids such as sand, clays, iron sulphide, rust, etc. stabilize water-in-oil emulsions. In addition, organic solids such as asphaltenes and paraffin can also provide stability to emulsions. Chemicals, for example cationic and anionic surfactants, are commonly added to produced fluids in order to break emulsions in the oil field. Heat and mechanical methods are also commonly used alone, or in conjunction with chemicals to destabilize and break emulsions into oil and water phases. Millions of dollars are spent each year in chemical treating and heating costs for control of emulsions.

US-A-3200567 discloses the use of ultrasonic treatment in the frequency range of 200 kHz to 400 kHz to break oil-water emulsions in a continuous flow treatment.

US-A-3594314 discloses the use of ultrasonic treatment in the frequency range of 10 to 200 kHz to break oil-in-water emulsions.

US-A-2257997 also shows the use of ultrasonics in breaking oil-water emulsions. Sonic waves have been used in a hollow chamber of uniform cross-section to separate components of a fluid mixture as described in US-A-4280823.

US-A-4339247 describes the use of an acoustic transducer attached to a hollow chamber that generates acoustic energy which separates dissolved gases from liquids introduced into the hollow chamber.

US-A-4411814 teaches the use of polyamines and/or polyamine salts as demulsifiers.

US-A-4737265 teaches the use of oxyalkylated alkyl-phenol formaldehyde resins as demulsifiers.

The present invention provides an effective and economical method to enhance breaking emulsions containing oil and water.

According to one aspect of the present invention there is provided a method for breaking an emulsion comprising oil and water into oil and water phases, comprising subjecting the

emulsion to sonic acoustic energy in the frequency range of about 1.0 to 10.0 kHz to enhance breaking the emulsion into a water phase and an oil phase.

Advantageously, the method further comprises adding a chemical demulsifier to the emulsion, preferably before subjecting it to the sonic acoustic energy.

The chemical demulsifier is desirably selected from the group consisting of quaternary ammonium chloride/polyols, cationic quaternary amines and polyoxylated phenolic resin/sulphonates/polyols.

The chemical demulsifier may be present at concentrations up to 0.1 percent by volume based on the volume of the emulsion.

The emulsion is preferably heated to a predetermined temperature prior to step adding the demulsifier.

Advantageously, the method further comprises separating the water from the oil phase. The separation of the water phase and the oil phase is preferably enhanced by heating the mixture to a temperature in the range 20°C to 82°C: when the oil is a light oil having an API gravity greater than 20, this temperature is preferably in the range 20°C to 65°C; when the oil is a heavy oil having an API gravity of 20 or less, this temperature is preferably in the range 45°C to 82°C.

The method works best using when the frequency of the sonic acoustic energy is 1.25 kHz.

The emulsion may be a water-in-oil emulsion or an oil-in-water emulsion.

In a particularly preferred embodiment the emulsion is injected into a hollow chamber of uniform cross-section having upper and lower flat surfaces and a pair of sides wherein the distance between the upper and lower surface is substantially less than the distance between the pair of sides, and the sonic energy is produced in the hollow chamber by means of an acoustic transducer attached to the upper or lower outer surface of the hollow chamber thereby enhancing the breaking of the emulsion into a water phase and an oil phase.

Preferably, the frequency of the acoustic transducer is the resonant frequency. Preferably also, the acoustic transducer is

attached to the mid-section of the outer upper or lower surface of the chamber.

According to another aspect of the present invention there is provided apparatus for separating an emulsion comprising oil and water into oil and water phases, comprising:

(a) a hollow chamber having an entrance port, said entrance port having upper and lower surfaces and a pair of sides wherein the distance between the upper and lower surfaces taper to a fixed distance and wherein the distance between the sides increase to a fixed distance forming an entrance zone;

(b) an acoustic zone communicating with the entrance zone having upper and lower flat surfaces and a pair of sides, said distance between the upper and lower surfaces being substantially less than the distance between the pair of sides, said acoustic zone having a uniform cross-sectional area substantially equal to the cross-sectional area of the entrance port;

(c) an exit zone communicating with the acoustic zone and an exit port communicating with the exit zone, said exit zone and exit port being a mirror image of the entrance port and entrance zone; and

(d) a transducer attached to the upper or lower outer surface of the acoustic zone to generate sonic energy in the frequency range of about 1.0 to 10.0 kHz.

Preferably, the acoustic zone is generally rectangular in shape. The transducer is preferably attached to the mid-section of the upper or lower outer surface of the acoustic zone.

Desirably, the area of the upper and lower surfaces of the acoustic zone is substantially 48 square inches (0.03 m^2). The thickness of the acoustic zone is preferably in the range of 0.125" (0.3 cm) to 0.75" (1.9 cm).

It is preferred that the entrance port, the entrance zone, the acoustic zone, the exit zone and the exit port are welded together. It is also preferred that the apparatus is formed by flattening the tube in the centre portion thereof.

Reference is now made to the accompanying drawings, in

which:

Fig. 1 is a flow sheet schematically illustrating a preferred procedure for treating a petroleum well stream in accordance with the invention;

Fig. 2 is a side elevation view of a preferred embodiment of the acoustic chamber;

Fig. 3 is a top elevation view of the acoustic chamber of Fig. 2; and

Fig. 4 is a diagram of the acoustic transducer.

Referring to Fig. 1, an emulsion of the water-in-oil type containing heavy crude oil having an API gravity of 20 or less and water is produced from a production well or wells and is introduced through line 10 into a free water knock out (FWKO) drum 12 where it is allowed to settle to separate the free water by gravity separation from the water-in-oil emulsions. The water in the heavy oil is generally present in the form of a water-in-oil emulsion and free water. Usually such emulsions will contain from about 10 to 90% wt% water based on the weight of the emulsion. Just prior to the FWKO drum 12, a small volume (about 2%) of recycled light hydrocarbon condensate is injected into line 10 via line 14 to improve the flow properties of the heavy oil/emulsion.

About 40% of the free water is separated from the water-in-oil emulsion in the FWKO drum 12 by gravity separation and recovered as a lower phase through line 16. The upper phase water-in-oil emulsion is removed from the FWKO drum 12 through line 18 and a chemical demulsifier additive is injected into the water-in-oil emulsion through line 20 to break the emulsion. The additive may be used in any effective amount up to about 0.1 vol% of the emulsion: preferably about 0.0125 to about 0.075 vol%.

The mixture is then fed through an acoustic chamber 22 wherein the water-in-oil emulsion/additive mixture is subjected to a low frequency within the sonic range of about 1.0 to 10.0, preferably 1.25 kHz, that increases or enhances the rate of breaking the emulsion. The flow rate into the acoustic chamber is about 1000 to 3000 barrels per day, preferably 2000 barrels

per day. The acoustic, or sonic, energy needed to enhance breaking the water-in-oil emulsion is in the low frequency sound spectrum. Depending on the resonant frequency of the sonic power, the required frequency may range from 500 hertz (Hz) to 10 kilohertz (kHz). Operating at the resonant frequency of the sonic source is desirable, because maximum amplitude, or power, is maintained at this frequency. Typically, this frequency is from 1.0 kHz to 10.0 kHz for the desired equipment, preferably 1.25 kHz.

Sonic energy in the low frequency range enhances separation of the water-in-oil emulsions by the following mechanisms: 1) efficient mixing of chemical demulsifiers without re-emulsification of the water and oil resulting in reduced interfacial tension; 2) violent mixing action is exerted on the individual water droplets resulting in the droplets of water coalescing at a greater rate into a water phase; 3) lowering interfacial tension and viscosity; 4) fast degassing of fluid; 5) separating solids and water by difference in density; 6) dispersing and oil wetting solids which remain in or, diffused into the oil phase; and, 7) destabilizing the oil/water/solids interface to promote separation.

The broken emulsion containing the water phase and oil phase exiting the acoustic flow chamber 22 is then fed into an oil-water separator tank 24 via line 26 where the emulsion is heated to a temperature in the range of 45°C to 82°C, and is allowed to settle to separate the water phase from the oil phase by gravity separation. The oil-water separator tank 24 is essentially a large vessel wherein an emulsion is heated by immersed heater tubes and travels over trays or through a filtering medium to separate oil and water. Water is recovered from the separator tank 24 as a lower phase and withdrawn through line 28. Oil is recovered from the separator tank 24 as an upper phase and withdrawn through line 30.

The oil recovered from settling tank 24 contains about 1 to 5 wt% water. If desired, a plurality of separator tanks may be used in parallel to separate the oil from the water. Average residence time of oil in a separator tank is in the order of

about 1.5 to 4 hours.

The oil is then passed through line 30 to a series of flash drums 32 where the oil is heated to a temperature of about 125°C. In the flash drums 32 any remaining water and light hydrocarbons are flashed off to an oil/water separator (not shown) where they are condensed and separated by gravity separation. The resulting recovered light hydrocarbon are then recycled into the heavy water-in-oil emulsion in line 10 to improve the flow properties of the heavy oil/emulsion.

The heavy oil, containing less than 0.5 wt% water, is withdrawn from the flash drums 32 via line 34 and fed to a shipping tank 36.

Figs. 2 and 3 depicts the acoustic chamber 22: it consists of an entrance port 38 with external screw threads 40 for connection with line 18. Referring to Fig. 2, the distance between the upper and lower surfaces 42 and 44 of the entrance port 38 taper to a fixed distance 46. Referring to Fig. 3, the distance between both sides 48 of the entrance port 38 increase to the fixed position 46 to form an entrance zone 50. Entrance zone 50 is connected to an acoustic zone 52. Referring to Fig. 2, acoustic zone 52 is enclosed by upper and lower flat surfaces 54 and 56 and as shown in Fig. 3, a pair of sides 58. The sides 58 of the acoustic zone 52 may, for example, be flat, arcuate or pointed.

Acoustic zone 52 is of uniform cross-section and the cross-sectional area is substantially equal to the cross-sectional area of entrance port 38 to prevent any chance of turbulence and re-emulsion of the oil and water. The thickness of the acoustic zone 52 is substantially less than the width of the upper and lower surfaces 54 and 56.

The other end of the acoustic chamber 22 is provided with an exit zone 60 and an exit port 62 which are mirror images of entrance zone 50 and entrance port 38. Exit port 62 is also provided with external screw threads 64 for connection to line 26.

A transducer 64 is attached to the upper surface 54 of the acoustic zone 52, preferably in the mid-section of the upper

surface. The dimensions of the acoustic zone 52 are nominal, but are proportionate to the size and power output of the driving transducer 64. Recommended dimensions of the upper and lower surfaces 54 and 56 of the acoustic zone 52 are about 6" to 8" (15 cm to 20 cm) length and about 6 to 8" (15 cm to 20 cm) width; and the recommended thickness of the acoustic zone 52 is about 0.125" to 0.75" (0.3 cm to 1.9 cm), preferably 0.375" (0.95cm).

The length of the entrance zone 50 and exit zone 60 is proportional to the outside diameter (OD) of the entrance port 38 and the width 47 of the acoustic zone 52 to maintain laminar flow. The diameter of the entrance port 38 will vary depending upon the diameter of the existing piping in the plant connected to the acoustic chamber 22.

The acoustic chamber 22 may be fabricated from stainless steel or other materials by conventional means or formed by flattening metal tubing.

The sonic energy is generated by a transducer 64 of the electrical-acoustic type adapted to convert electrical energy into mechanical vibrations that are introduced into the acoustic zone 52. The upper and lower flat surfaces 54 and 56 of the acoustic zone 52 function as plates that contain the acoustic energy. The transducer 64 is a magnetostrictive transducer. A suitable transducer is manufactured under the trade designation "T"-Motor by Sonic Research Corporation, Moline, Illinois, that generates sonic vibrations having a frequency within the range of about 1.0 to 10.0 kHz.

In the embodiment of Fig. 4, the transducer consists of a magnetostrictive material in the form of rods 66 compressed together and wrapped with a wire coil 68. The opposite ends 70 and 72 of rod 66 abut permanent magnets 74 and 76 respectively. The end 76 of rod 66 is abutted by a pre-stress washer 78 and connected to actuator rod 80. The coil 68, magnet 74 and pre-stress washer 78 are encased in a casing 82. The rods 66 comprise 90% iron, 5% terbium and 5% dysprosium sold under the trade designation "Terfenol-D" by Edge Technologies, Inc., Ames, Iowa. The Terfenol-D rod is the only material known that can

produce variable frequency, and withstand high temperature and pressure.

The rods vibrate lengthwise when a DC current flows through the coil 68. The induced magnetic field causes the rods to expand and contract, i.e. magnetostrictive motion. This motion, or vibration, generates an acoustic wave or sonic energy having a frequency in the range of 0.5 to 10.0 kHz which extends forward from the transducer for some distance. The transducer is powered by a standard frequency generator and a power amplifier. A suitable transducer for use in the present invention is disclosed in US-A-4907209.

The chemical demulsifier may be any one selected from those which can be employed to assist in the breaking and separating of water and oil phase from emulsions. Preferably, the demulsifier is selected from the group consisting of quaternary ammonium chloride/polyols sold by Baker Performance Chemicals Inc. of Houston, TX, under the tradename AQUANOX 9EB-371, cationic quaternary amines sold by Baker Performance Chemicals, Inc., of Houston, TX, under the tradename AQUANOX 9EB-272 and polyoxylated phenolic resin/sulphonate/polyols sold by Baker Performance Chemicals, Inc., of Houston, TX, under the tradename AQUANOX 9EB-395.

In an alternate embodiment of the invention, if the emulsion contains light oil having an API gravity greater than 20, the emulsion can be broken by subjecting it to acoustic energy in the frequency range of about 1.0 to 10.0 kHz, preferably 1.25 kHz, without the addition of a chemical demulsifier. In the practice of this alternate embodiment, the steps of the method would be the same as previously described except for the step of adding a chemical demulsifier and heating the broken emulsion in the oil-water separator tank 24 to a lower temperature in the range of about 20°C to about 65°C.

The present invention results in at least a reduction of 75% of chemical demulsifier normally used to break water-in-oil emulsions produced from oil fields in addition to reducing heating costs. The present invention provides a very effective method for enhancing breaking water-in-oil emulsions that is

more economical and efficient than other methods presently in use. For example, 1,570 barrels of a produced water-in-oil emulsion containing 50% water using a chemical demulsifier additive enhanced with acoustic energy in the low frequency range required 37.5 litres per day less of the chemical additive to break the emulsion than when using conventional means. Decreasing the amount of additives required to break water-in-oil emulsions saves millions of dollars each year. In addition, the use of low frequency sonic acoustic energy to enhance breaking water-in-oil emulsions also significantly reduces the amount of heat required to separate the oil phase from the water phase after the emulsion has been broken since the emulsion is more efficiently coalesced and broken in the presence of low frequency sonic energy. Therefore, the present invention significantly reduces chemical treating and heating costs for breaking water-in-oil emulsions.

The following example describes more fully the present method. However, this example is given for illustration and are not intended to limit the invention.

Example

Example for Emulsion Treating with Acoustic Energy at 1.25 kHz:

First Day: Acoustic energy unit installed and system equilibrated; an oil field water-in-oil emulsion containing about 90% water was fed into a free water knock out (FWKO) drum. In the FWKO drum the emulsion was allowed to settle to separate the free water from the emulsion by gravity separation. The water-in-oil emulsion fluid flow from the free-water knock out (FWKO) drum was heated to a temperature of about 40°C to about 42°C and then fed into an oil-water separator tank at the rate of 1,510 barrels/day (B/D); AQUANOX 272 de-emulsifier chemical additive was injected into the water-in-oil emulsion at the rate of 50 litres/day (L/D) prior to the separator tank. The chemically treated emulsion injected into the separator tank was heated to about 80 to 82°C and the average residence time in the separator tank was 4.8 hours for the water phase and 13.4 hours for the oil phase.

Second Day: Emulsion flow from the FWKO drum (heated to 40 to 42°C) was maintained at 1,510 barrels/day, chemical addition (AQUANOX 272) was reduced to 25 litres/day and the water-in-oil emulsion was subjected to acoustic energy at 1.25 kHz prior to the separator. Separated water was clean in the separator tank and oil was free of water.

Third day: Acoustic energy unit turned off and chemical additive (AQUANOX 272) rate had to be increased to 50 litres/day to break the emulsion. The water in the separator tank was dirty and the separation of water and oil in the separator tank was difficult with water remaining in the emulsion.

Fourth day: Acoustic energy unit turned back on at a frequency of 1.25 kHz which allowed the chemical additive (AQUANOX 272) rate to be reduced to 15 litres/day to break the emulsion. This resulted in clean water and a clean oil/water separation in the separator tank. Basic sediment and water (BS&W) analysis was zero with a small amount of solids in the oil. Chemical additive injection was then discontinued for 8 hours. BS&W indicated a small amount of water in the separated oil; returned chemical additive (AQUANOX 272) injection to 25 litres/day.

Fifth day: The water/oil interface in the separator tank was clean and free of solids; chemical additive (AQUANOX 272) rate maintained at 25 litres/day and emulsion subjected to acoustic energy at a frequency of 1.25 kHz. Observed clean water in separator tank, good oil/water separation and no water present in BS&W tests. Solids were oil-wet and carried over with the oil to the flash drum.

In the above example, the average amount of residual water in the oil recovered from the separator tank without acoustic treatment was about 1-5 wt%, but when acoustic energy was applied at a frequency of 1.25 kHz, residual water was not detectable in the oil recovered from the separator tank. The above example shows that when the chemical demulsifier additive is reduced and acoustic energy is not applied the water-in-oil emulsion was not efficiently broken, but when acoustic energy was applied in conjunction with a reduced amount of chemical

demulsifier additive, breaking of the emulsion was efficient. Also, the residence time of the fluids in the separator tank was significantly reduced with the application of acoustic energy at a frequency of 1.25 kHz in conjunction with the addition of a reduced amount of the chemical demulsifier additive. In fact the oil entering the separator tank was normally free of water and the water was also free of solids.

Claims

1. A method for breaking an emulsion comprising oil and water into oil and water phases, comprising subjecting the emulsion to sonic acoustic energy in the frequency range of about 1.0 to 10.0 kHz to enhance breaking the emulsion into a water phase and an oil phase.

2. A method according to claim 1, further comprising adding a chemical demulsifier to the emulsion.

3. A method according to claim 2, wherein the demulsifier is added prior to subjecting the emulsion to sonic acoustic energy.

4. A method according to claim 2 or 3, wherein the chemical demulsifier is selected from the group consisting of quaternary ammonium chloride/polyols, cationic quaternary amines and polyoxylated phenolic resin/sulphonates/polyols.

5. A method according to claim 1, 2, 3 or 4, wherein the chemical demulsifier is present at concentrations up to 0.1 percent by volume based on the volume of the emulsion.

6. A method according to any one of claims 2 to 5, wherein the emulsion is heated to a predetermined temperature prior to adding the demulsifier.

7. A method according to any preceding claim, further comprising separating the water from the oil phase.

8. A method according to claim 7, wherein the separation of the water phase and the oil phase is enhanced by heating the mixture to a temperature in the range 20°C to 82°C.

9. A method according to any preceding claim, wherein the oil is a light oil having an API gravity greater than 20.

10. A method according to claim 9, when dependent upon claim 7, wherein during the separation of the water phase and the oil phase is enhanced by heating the mixture to a temperature in the range 20°C to 65°C.

11. A method according to any one of claims 1 to 8, wherein the oil is a heavy oil having an API gravity of 20 or less.

12. A method according to claim 11, when dependent upon claim 7, wherein during the separation of the water phase and the oil phase is enhanced by heating the mixture to a temperature of about 45°C to about 82°C.

13. A method according to any preceding claim, wherein the frequency of the sonic acoustic energy is 1.25 kHz.

14. A method according to any preceding claim, wherein the emulsion is a water-in-oil emulsion.

15. A method according to any one of claims 1 to 13, wherein the emulsion is an oil-in-water emulsion.

16. A method according to any preceding claim, wherein the emulsion is injected into a hollow chamber of uniform cross-section having upper and lower flat surfaces and a pair of sides wherein the distance between the upper and lower surface is substantially less than the distance between the pair of sides, and the sonic energy is produced in the hollow chamber by means of an acoustic transducer attached to the upper or lower outer surface of the hollow chamber thereby enhancing the breaking of the emulsion into a water phase and an oil phase.

17. A method according to claim 16, wherein the frequency of the acoustic transducer is the resonant frequency.

18. A method according to claim 16 or 17, wherein the acoustic transducer is attached to the mid-section of the outer upper or

lower surface of the chamber.

19. Apparatus for separating an emulsion comprising oil and water into oil and water phases, comprising:

(a) a hollow chamber having an entrance port, said entrance port having upper and lower surfaces and a pair of sides wherein the distance between the upper and lower surfaces taper to a fixed distance and wherein the distance between the sides increase to a fixed distance forming an entrance zone;

(b) an acoustic zone communicating with the entrance zone having upper and lower flat surfaces and a pair of sides, said distance between the upper and lower surfaces being substantially less than the distance between the pair of sides, said acoustic zone having a uniform cross-sectional area substantially equal to the cross-sectional area of the entrance port;

(c) an exit zone communicating with the acoustic zone and an exit port communicating with the exit zone, said exit zone and exit port being a mirror image of the entrance port and entrance zone; and

(d) a transducer attached to the upper or lower outer surface of the acoustic zone to generate sonic energy in the frequency range of about 1.0 to 10.0 kHz.

20. Apparatus according to claim 19, wherein the acoustic zone is generally rectangular in shape.

21. Apparatus according to claim 19 or 20, wherein the transducer is attached to the mid-section of the upper or lower outer surface of the acoustic zone.

22. Apparatus according to claim 19, 20 or 21, wherein the area of the upper and lower surfaces of the acoustic zone is substantially 48 square inches (0.03 m^2).

23. Apparatus according to claim 19, 20, 21 or 22, wherein the

thickness of the acoustic zone is in the range of 0.125" (0.3 cm) to 0.75" (1.9 cm).

24. Apparatus according to any one of claims 19 to 23, wherein the entrance port, the entrance zone, the acoustic zone, the exit zone and the exit port are welded together.

25. Apparatus according to any one of claims 19 to 24, wherein the apparatus is formed by flattening the tube in the centre portion thereof.

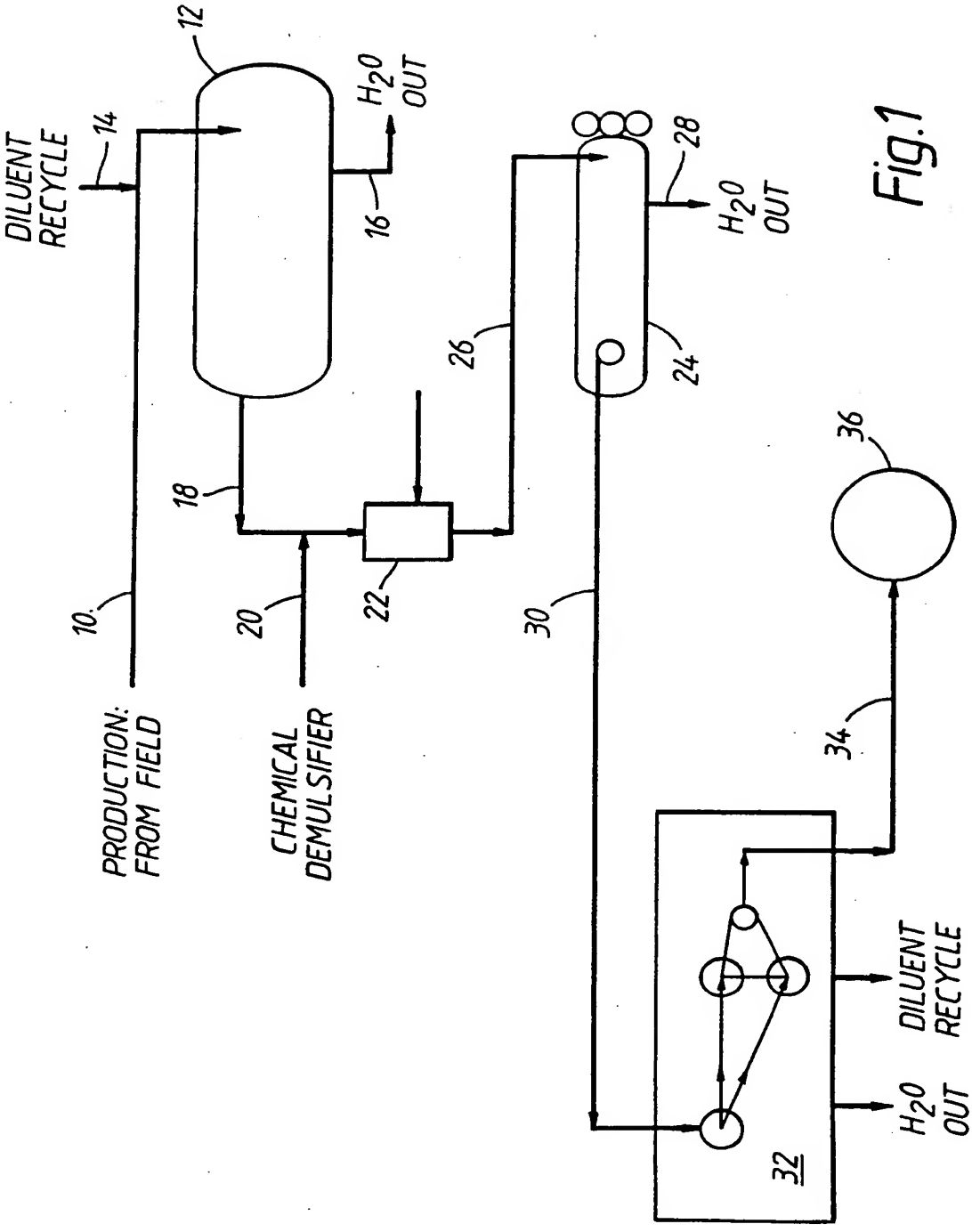
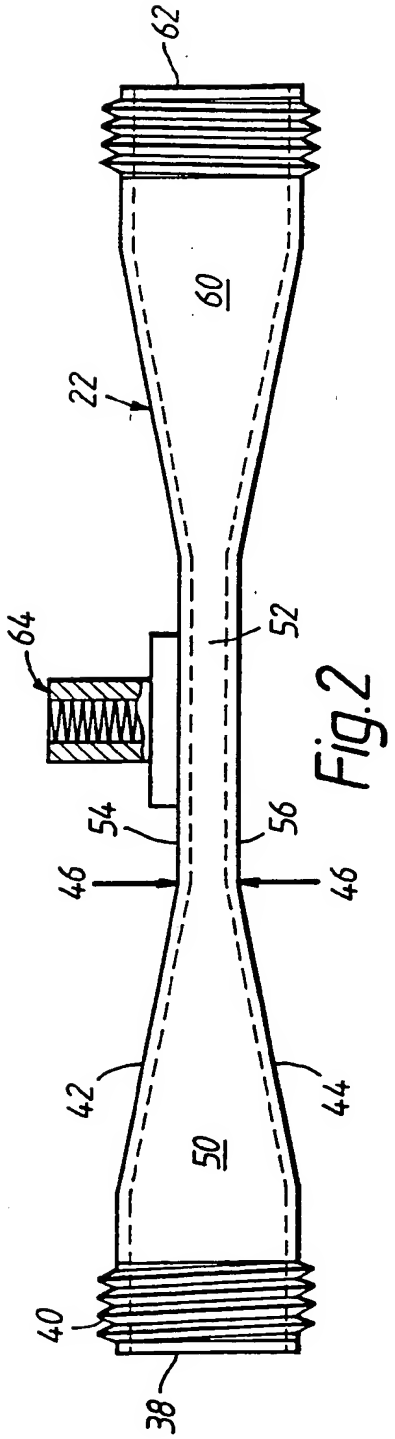

DILUENT RECYCLE
14
12
H_2O OUT
16
18
10
20
22
26
28
H_2O OUT
24
36
30
34
PRODUCTION: FROM FIELD
CHEMICAL DEMULSIFIER
32
DILUENT RECYCLE
H_2O OUT

Fig.1


62
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22
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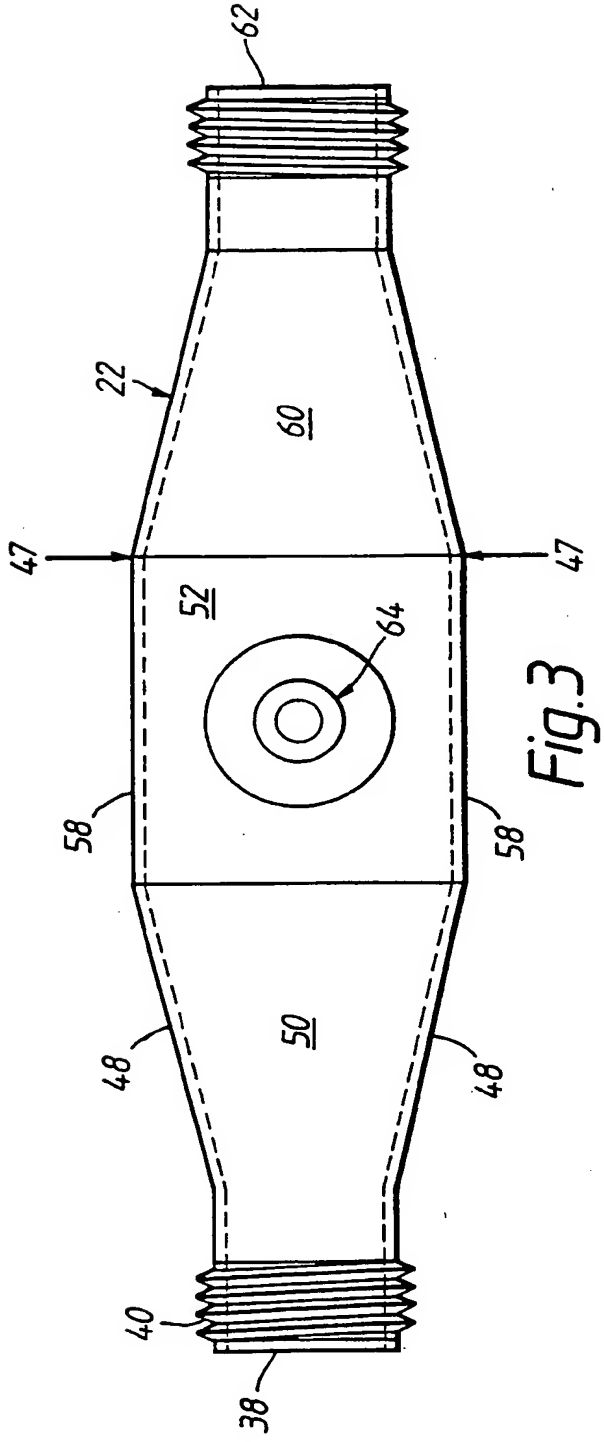
52
54
56
46
46
42
44
50
40
38

Fig.2


62
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60
47
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64
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Fig.3

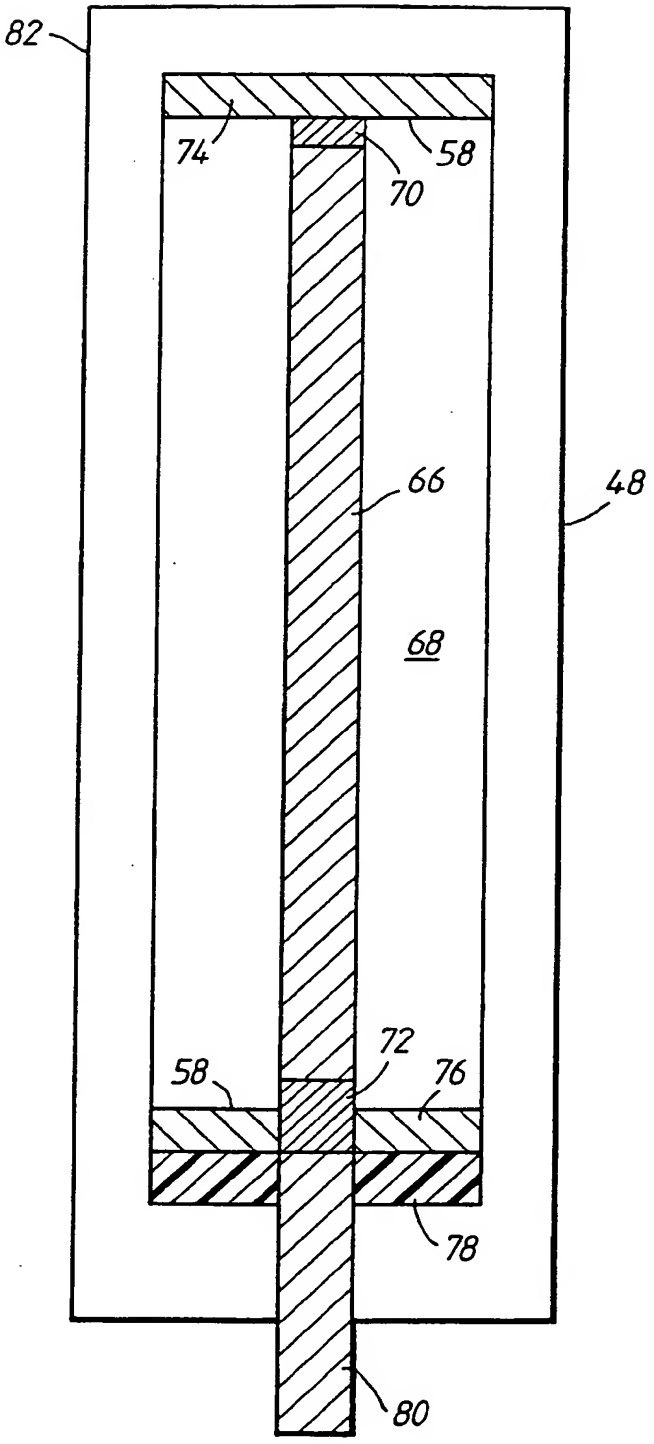

Fig.4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/07604

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : C07C, 7/00
US CL : 204/157.15

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 204/157.15, 157.42, 158.20, 158.21
210/748; 422/128

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS water, oil, emulsion, separating, sonic, acoustic demulsifier, ultrasonic, agitation, polyols, quaternary ammonium chloride

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A 3,594,314 (Bilhartz) 20 July 1971, abstract; col. 6, lines 27-36; col. 7, lines 27-33 and lines 48-50; claim 1.	1-18
Y	US,A, 2,257,997 (Barnes) 07 October 1941, Col. 2, lines 5-10 and lines 20-26; Col. 3 lines 39-59; examples 1 and 2	1-18
Y,P	US,A, 5,344,532 (Joseph) 06 Sepember 1994, Col. 2, lines 26-29 and lines 38-41.	1-18
Y	US,A, 4,280,823 (Szonntagh) 28 July 1981, Col. 2, lines 18-48.	19-25
Y	US,A, 3,200,567 (May) 17 August 1965, figure 7; Col. 3, lines 32-46.	19-25

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 JULY 1995	22 SEP 1995

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